Occurrence of Gibbsite Amygdules in Haiku Bauxite Area of Maui[1]

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AREAS OF BAUXITE DEPOSITS have been discovered on the islands of Kauai, Maui, and Hawaii of the Hawaiian Islands. These deposits have been described by Sherman (1957) and Fellom (1957). In many of these deposits the free aluminum oxide occurs as a constituent of irregular-shaped nodules varying in size from 1/100 inch to over 6 inches in their longest dimensions. The alumina content of these nodules as determined in the laboratories of the Hawaii Agricultural Experiment Station ranges from 40 per cent to 62 per cent. Iron oxide was found to be the other major constituent of these nodules ranging from a little over 2 per cent to 40 per cent. Mineralogical analysis of the nodules has identified the minerals as gibbsite, the trihydrate of aluminum oxide, and goethite, an iron oxide.

Recently, layers of pea-sized gibbsite amygdules were found in several of the deep road-cuts occurring on the new highway to Hana, 3–5 miles east of Pauwela, Maui. The white gibbsite amygdules are exposed in the banks of the road-cuts as irregular layers from 12 to 20 feet below the surface soil. These layers are easily recognized because the numerous white amygdules occur in dark gray brown rocks which are completely weathered. These weathered rocks still retain the structure of the original parent rock. The material is soft and when crushed between one's fingers it readily breaks down to a clayey material, and the hard round amygdules. The amygdules are shown in Figure 1.

A close examination of the amygdules revealed that they have been developed by the precipitation of hydrated aluminum oxide in the cavities of the parent rock. The unfilled cavities can be found in adjacent parent rock and in the unweathered rock of the same formation. The cavities were formed by gas bubbles in the original lava. The precipitation of the aluminum oxide initially occurred on the wall of the cavity. Subsequent precipitation of additional aluminum oxide has continued until the cavity was completely filled. The contents of the cavity harden to form a resistant amygdule. The size and shape of the cavity determine the physical shape of the amygdule. The aluminum is transported in percolating waters to the cavity as aluminum hydroxide and is precipitated as the hydroxide on exposure to air in the cavity. It then is converted to trihydrate of aluminum oxide on aging in a drier atmosphere. The evidence for the mode of deposition of the aluminum oxide in the cavities is as follows: (a) the occurrence of similar unfilled cavities having similar shapes and volume in the adjacent weathered material, (b) the concentric deposition layers of the amygdule, (c) the occurrence of hollow amygdules which would indicate the initial precipitation of the hydrated oxide on the wall of the cavity (several of the amygdules in Fig. 1 have hollow centers), and (d) the observation of the formation of aluminum and iron oxides on exposure of seepage waters exuding from ditch and road cuts during the wet season.

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[1] Published with the approval of the Director of the Hawaii Agricultural Experiment Station as Technical Paper No. 400. Manuscript received September 25, 1957.

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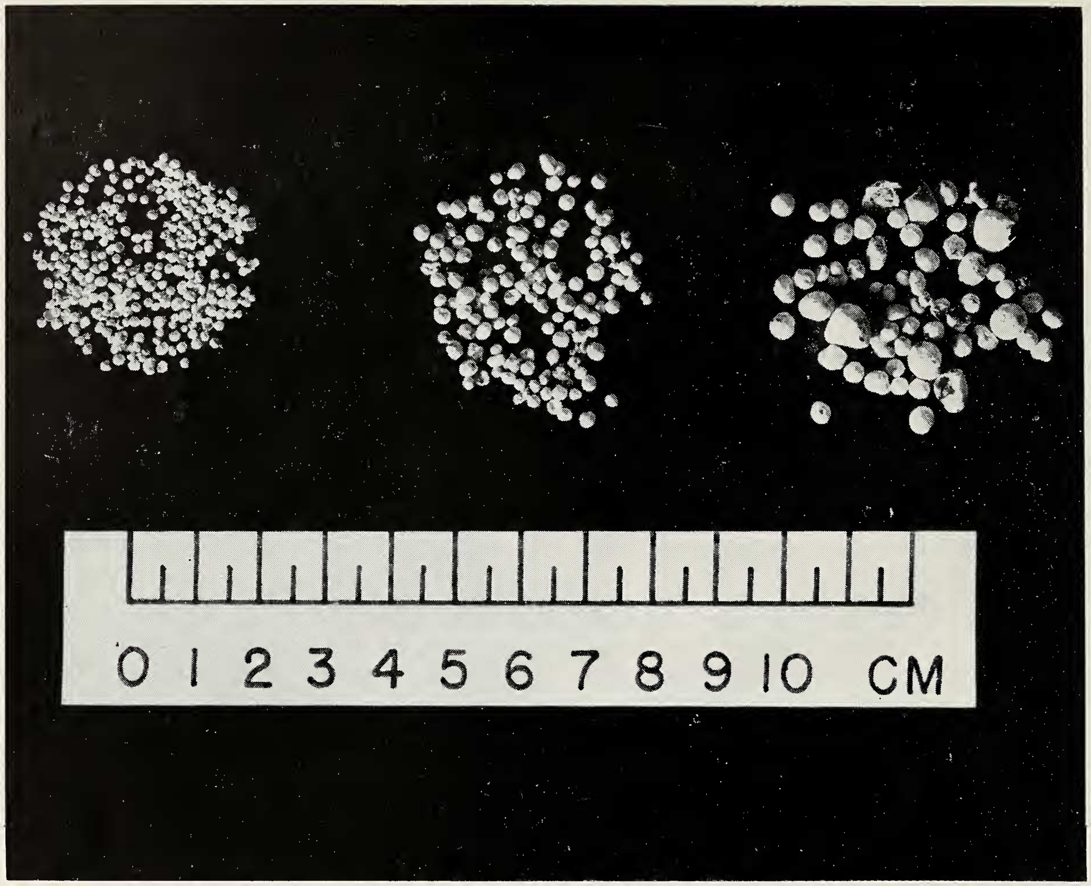

FIG. 1. Samples of gibbsite amygdules from Haiku bauxite area east of Pauwela, Maui. Samples on the right show outer skin of amygdule, some of which are hollow in the center.

Samples of the weathered rock containing the amygdules were collected to determine their chemical and mineral compositions. The amygdules were separated by dry-screening on a 20-mesh sieve and then any adhering matrix was removed by washing with distilled water. The samples of matrix and amygdules were dried and weighed. The chemical analysis of the samples of matrix and amygdules was made by procedures described by Piper (1944). The identification of the minerals in both the matrix and the amygdules was made by differential thermal analysis procedures proposed by Norton (1939). The samples were ground to pass through a 100-mesh sieve before analysis.

The chemical composition of the amygdules and their respective matrices is presented in Table 1. The samples of amygdules have a very uniform chemical composition which averages as follows: 1.6 per cent SiO_2; 61.7 per cent Al_2O_3; 5.8 per cent Fe_2O_3; 0.8 per cent TiO_2; and, a loss on ignition of 30.9 per cent. The chemical composition of the amygdules approaches that of the mineral gibbsite, the trihydrate of aluminum oxide. The theoretical analysis of gibbsite is approximately 66 per cent Al_2O_3 and a loss on ignition of 34 per cent. The average composition of the matrix is as follows: 2.5 per cent SiO_2; 27.9 per cent Al_2O_3; 44.0 per cent Fe_2O_3; 9.6 per cent TiO_2; and a loss of ignition of 15.0 per cent. The variation in chemical analysis of the samples of amygdules and matrix is extremely uniform. The remarkable fact brought out by the analyses is that the amygdules have a high concentration of aluminum oxide while the matrix has a high concentration of iron and titanium oxides. The silica content of both materials is very low. This same observation has been made in other types of precipitation of gibbsite from percolating waters.

The data presented in Figure 2 were obtained from the differential thermal analysis of a representative sample of the amygdules and the matrix. The strong endothermic peak occurring in these curves at temperatures between 350° C. and 375° C. is due to the minerals gibbsite and goethite. The endothermic action of gibbsite is much stronger than goethite, thus it is safe to identify the aluminum oxide mineral of the amygdule as gibbsite, the trihydrate of aluminum oxide.

The occurrence of gibbsite amygdules in the Hawaiian bauxite deposits is of considerable interest. Prior to their discovery, the gibbsite had been found only in nodular form and in sheets of aluminum oxide with iron oxide in seepage channels of percolating water. Pisolitic deposition of gibbsite has been described by Alexander *et al.* (1955). In the soils above the decomposed layer, the amygduloidal gibbsite occurs in aggregates and thus might easily be described as being a pisolitic occurrence of gibbsite.

They observed gibbsite fills in spaces left by shrinkage in the hardening of laterite. The recently discovered bauxite of Cape York, Australia, is a pisolitic type of concentration. Its development has been attributed to the flooding of the coastal areas during the cyclones of the monsoon season and its subsequent drying. The development of pisolites

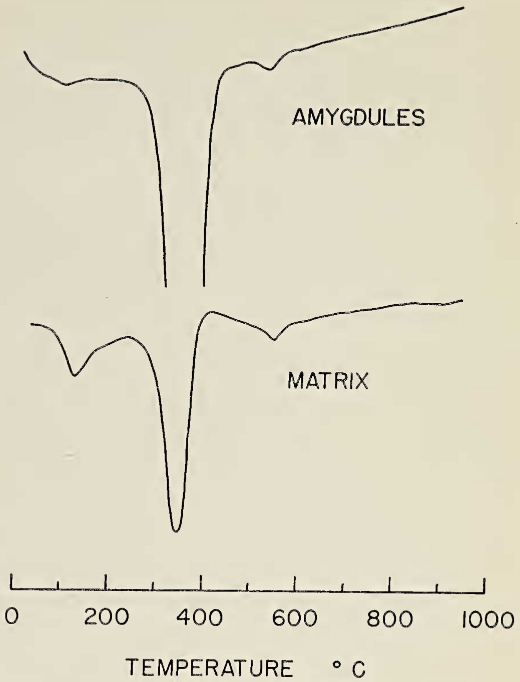

FIG. 2. The representative differential thermal analysis curves of a sample of amygdule and the matrix. Amygdules are from the Haiku bauxite area east of Pauwela, Maui.

TABLE 1
THE CHEMICAL COMPOSITION OF GIBBSITE AMYGDULES AND THEIR MATRICES FROM THE HAIKU BAUXITE AREA EAST OF PAUWELA, MAUI
(Samples from road-cuts on Hana road)

SAMPLES	SAMPLE PER CENT	SiO_2 PER CENT	Al_2O_3 PER CENT	Fe_2O_3 PER CENT	TiO_2 PER CENT	LOSS ON IGNITION PER CENT
Amygdules A	51.1	1.54	61.72	5.64	0.80	30.96
Matrix A	48.9	2.43	28.68	45.37	9.43	15.11
Amygdules B	49.5	1.65	61.60	5.83	0.73	31.06
Matrix B	50.5	2.65	27.80	46.30	9.62	14.92
Amygdules C	50.4	1.72	61.72	6.08	0.88	30.60
Matrix C	49.6	2.52	27.24	46.42	9.62	14.84

and amygdules of gibbsite depends upon wet and dry conditions to provide the means of movement of the alumina in order to produce the rhythmic precipitation which is so characteristic of their structure.

SUMMARY

The occurrence of gibbsite amygdules in a bauxite deposit of the Haiku area of Maui has been described. The amygdules are formed by the rhythmic precipitation of hydrated aluminum oxide in cavities which are relics of the parent rock. These cavities were probably gas bubbles in the original lava. The amygdules contain approximately 62 per cent Al_2O_3, 6 per cent Fe_2O_3, and trace amounts of silica and titania. The hydrated aluminum oxide has been identified as gibbsite by differential thermal procedures.

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